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An Assessment of The Concentration of Heavy Metals in Soils and Vegetables in Fadama Sites Along Farin-Gada Bridge, Jos, Plateau State

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Abstract

The study assesses the concentration of heavy metals in soils and vegetables in Fadama sites along Farin-Gada in Jos Metropolis. Samples of vegetables (cabbage and lettuce) and soils were collected from selected Fadama farms and analysis was made for six (6) different heavy metals. These include Lead (pb), Chromium (Cr), Cadmium (Cd), Copper (Cu), Zinc (Zn) and Nickel (Ni). The study site was subdivided into two located at either sites of the River Delimi. Twelve (12) sample points were chosen for all sides of the river (FGB 1-12) for soil samples while six (6) points were chosen for vegetable samples (FGV1-6). These samples were analyzed in the laboratory for heavy metals using Atomic Absorption Spectrometer (AAS) for soils and vegetables and the results were subjected to statistical analysis of Mean, Standard Deviation, Coefficient of Variation, ANOVA, Correlation and Regression. The findings revealed that Lead (pb) and Chromium (Cr) had the highest values of 0.092ppm and 0.08ppm respectively, while Zinc (Zn) and Copper (Cu) had the lowest values of 0.02 and 0.01 respectively. The values were above the WHO approved standard. This may be attributed to the cosmopolitan nature of the area where a lot of human activities are carried out. The study also shows that strong relationship existed between soil and vegetables in the study area, Cu had the highest R2 value of 0.86 while the relationship between vegetables with pb, Cd, Zn, Cr and Ni was weak. The study suggested that the use of chemical fertilizers which contain heavy metals should be strictly based on professional advice and that other likely sources of heavy metals such as water were not included in this research but given attention for further study.

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Introduction

Of recent, pollution of general environment has increasingly gathered a global interest. In view of this, contamination of agricultural soils with heavy metals has always been considered a critical challenge in scientific community (Faruk et al., 2006). Due to the cumulative behaviour and toxicity, heavy metals have a potential hazardous effect not only on crop plants but also on human health (Das *et al*., 1997). To a small extent they enter our bodies via food, drinking water and air. As trace elements, some heavy metals at higher concentrations can lead to poisoning. Heavy metals are dangerous because they tend to bioaccumulate. Bioaccumulation means an increase in the concentration of a chemical in a biological organism over time, compared to the chemical's concentration in the environment (Lenntech, 2004).

Soil acts as a key component of the natural ecosystems and environmental sustainability largely depends on a sustainable soil ecosystem and any alteration as a result of either pollution or contamination ultimately alters the ecosystems and agricultural activities are also greatly affected (Hong *et al.,* 2014). Such activities result in contamination in various forms. The contaminants present in the wastewater and soil pose health risks directly to agricultural workers and indirectly to consumers of the wastewater grown product (fodder crops, greens and vegetables), as the long-term application of the wastewater may result in the accumulation of toxic compounds such as heavy metals in soil and plants. In this way the heavy metals enter the food chain of animals and human and cause health hazards (Chandran *et al*., 2012). So, it is essential to monitor food quality, given that plant uptake is one of the main pathways through which heavy metals enter the food chain.

However, the beneficial and detrimental effects associated with the use of this contaminated water in agriculture are well known. Environmental contamination in some developing countries has been attributed to negative effect of technological developments such as Urbanization and industrialization, with poor planning in waste disposal and management (Rajagana Pathy *et al*., 2011). The factors that affect the distribution and occurrence of metals in the soil include soil pH, cation exchange capacity (CEC), organic matter content, soil texture and interaction among the target elements (Ojo, 2017). Heavy metals such as Fe, Cu, Zn, Mn and Ni though essential nutrients at trace levels, however, at high concentrations beyond stipulated levels could be toxic and harmful. Metals such as Pb, Cd and Cr are reported to be non-essential to man (Edebi and Gideon,2017).

Rivers are known to be the dominant Pathway for metals transport (Ikhuoriah and Oronsaye2016) and heavy metals become significant pollutants of many riverine systems. Waste water contains substantial amounts of toxic metal which create problems. Excessive accumulation of heavy metals in agricultural soils through wastewater irrigation may not only result in soil contamination but also affect food quality and safety (Nasir *et al*., 2017).

The river Delimi which passes across Jos city is viewed as a receptacle of infinite capacity, but it is now clear that man may be exceeding nature's capacity to assimilate its waste. Henry *et al*., (2016) observed that pollutants eventually decompose and diffuse throughout the environment. This takes place when organic substances are discarded. When they are attacked by bacteria, they decompose and simply rot. When these heavy metals enter human body, through drinking water or consumption of aquatic organisms and vegetables, it has a tendency to accumulate in particular organs (Even and Ghaffari, 2011).These heavy metals can be toxic at high concentrations, when ingested over a long period of time and affect not only the soils but the vegetable crops grown on the soil (Adewumi *et al.,*2017).

Due to rapid increase in human population, industrialization, urbanization over the years, human life styles and activities have tremendously affected the environment greatly. One of the most significant impacts is heavy metal pollution of farmlands as it serves as an intimate linkage to human food chain (Hong and Law, 2014). The accumulation of metals in agricultural farmland does not only decrease the productivity and quality of crops grown, but it also threatens the safety of ecosystem and human health in monumental dimension through its adverse effect.

As the world population increases, environmental degradation also increases. Pollution as one of the resultant effects has become a global concern and the need to control it by more information and evaluation of soil pollution is advocated (Henry *et al.* 2016). Sewage water as transported agent, carry heavy metals along with it into the soil which are distributed, deposited and accumulated in different localities (Mahmoud and El-Kader, 2015). Several studies have also indicated the presence of heavy metals in soils, vegetables and water.

According to Lente *et al.* (2014); Mustapha *et al.* (2014) and Alamgir *et al.* (2015), carried out different studies in different locations indicated that heavy metal concentration were above the recommended threshold limits of FAO and WHO where Cadmium (Cd) has a maximum permissible limit (MPL) of 3 µg/ml in soil, Chromium has 100 µg/ml (MPL) in soil, Nickel has 50 µg/ml and 67.00 µg/ml (MPL) in soil and vegetable respectively, Lead has a MPL of 100 µg/ml in soil and 0.30 µg/ml in vegetable, Zinc (zn) has a MPL of 300 µg/ml in soil and 100 µg/ml in vegetables while Copper has a MPL of 100 µg/ml in soil and 73.00 µg/ml in vegetables.

The Delimi River which drains the greater part of the Jos city is now acting as a combined sewer system into which thousands of tons of garbage of all sorts are dumped, is no doubt contaminated. For instance, the color of the water and the odor emanating from it portrays these elements of pollution in many parts of the river as it flows. Despite this apparent deterioration of the water in the river, it is still one of the major sources of livelihood for the urban and suburban population, serving both domestic and agricultural (Irrigation) purposes.

Furthermore, mining activity can be a risk factor in the contamination of soil, water and vegetables. Studies have indicated mine sites are around farmlands where toxic elements may accumulate in fruits and leaves of arable and cash crops, and that soil contamination in mine sites can cause severe heavy metal contamination of water sources and poisoning of humans and animals, if ingested (Bartrem *et al.*, 2015). The mining areas of which some streams drained to Delimi River is an added pollution to the water.

From the foregoing, it has been demonstrated that the use of industrial effluents and wastewaters for growing of vegetables have serious impacts in contamination of soils by heavy metals and subsequent accumulation of metals by vegetables. A number of research have been carried out on the concentration of heavy metals of certain crops around Jos and its environs. All these researches were carried out 5-10 years ago. Frequent assessment of heavy metals in the soil is very pertinent to be considered because of the continuous accumulation of the heavy metals in the area which may reduce the quality of soil and affect the ecosystem. Also, some of these studies considered the concentration of heavy metal in soil only; some in water only while some in vegetables. However, considering the concentration of heavy metals in soils and vegetables is very important to determine the level of bioaccumulation in the vegetables.

Study Area

The study area is located between Lat. 9°51''N to 10°3'N and Long. 8°48'E and 8°67'E (Fig 1).The Plateau surface occupies an area of some 8600km sq (Alford *et al.,* 1979) lying at about l ,200m and rises above 1400m to the south of Barkin Ladi and the east of Jos (Potter et al., 2002), and is bounded by 300-600m escarpments around much of its circumference.

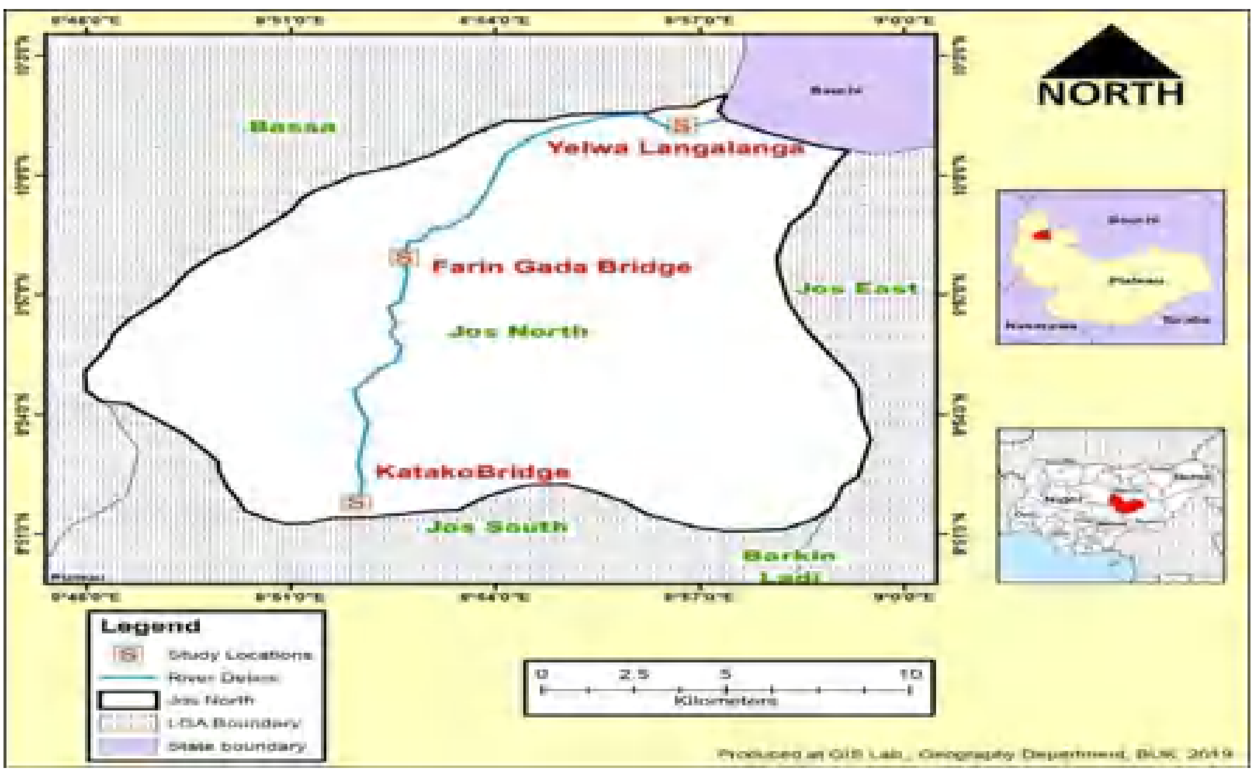

Fig 1: Jos North showing River Delimi and Sample site

Source: GIS Lab, Geography Department, BUK 2019.

The climate of the Plateau differs markedly from that of the surrounding plains. The seasonal migration of the Inter-Tropical Convergence Zone (ITCZ) governs the sequence of three seasons: a cool dry season (October to February), a hot season (March, April) and a wet season (May to September) (Alford *et al.,* 1979). Mean monthly temperatures range from 20 to 24°C (Potter et al., 2002). The relief of the Plateau and the direction of the air flow mean that rainfall is far from being uniform. The highest totals occur on the hilly western margin (particularly the south-western margin) and the lowest on the eastern plains of Panyam and Pankshin (Alford *et al.,* 1979).

Jos, at an altitude of 1,285m has a mean annual temperature of 21.8°C, ranging from 20.2°C to 24.3°C (mean monthly temperatures). Mean annual rainfall is 1,413mm and the rainy months (May to September) are each characterized by approximately 200 to 300mm (the peak rainfall period is July, with 321 mm). Outside of these months, rainfall drops off sharply (Alford *et al.,* 1979). Higher rainfall may occur locally around the Shere Hills. The rains start in April and stops in October.

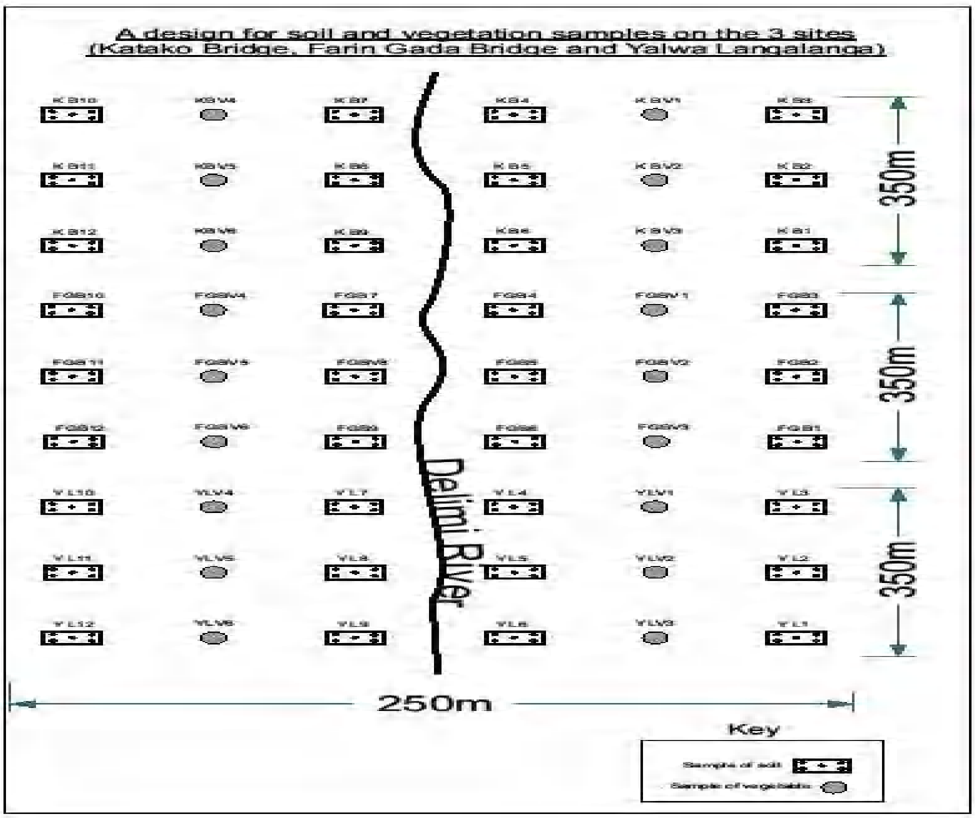

Figure 1Fig. 3. A design for Soil and Vegetable samples along Farin-Gada bridge

The Jos Plateau is considered the 'hydrological centre' of the country. The drainage is radial and the watersheds of three major river systems of the country come together at a point near Rayfield. The Delimi River drains to Lake Chad; the Gongola, Wase, Shemankar, Ankwe and Mada Rivers drain into the Benue, and the Kaduna River into the Niger (Alford *et al.,* 1979).

Having selected the 3 sites using GPS, the sites were mapped and further sub divided into plots at the left and right sides of the river banks, 10m away from the river. The sites range from 2-3 ha in size. Each site (location) was then divided into plots where twelve (12) sample points were selected for soil samples, six points at either side of the river (fig 3.0). For vegetable samples, twelve (12) points each were selected for each location, three (6) points in each side of the river. All these were done using purposeful sampling technique for point composite. Each sample point was 100m separated from the other for both soil and vegetable samples in all the sites.

Twelve soil samples of soil and vegetables were taken from each location giving a total of 36 sample points for both soil and vegetables. The leaves of the vegetables (Cabbage and lettuce) were taken for the study. The exact sampling sites were established using GPS in order to get the exact location of the sampling sites.

Fig 2: Map of Farin-Gada bridge showing Fadama Site
Source: Google Earth, (2019).

Soil samples

Soil samples were taken at the depths of 0-15cm for all the sample points. Samples were collected into polyethylene bags, labeled and properly tied. In the laboratory, the soil samples were spread on glass plates and then dried in an oven at 60°C for six hours. The dried soil was grounded and sieved through 2mm mesh sieve for the analysis of heavy metals as Cd, Cr, Ni, Zn, pb and Cu. One gram each of the ground soil samples was weighed into a 125 ml beaker and digested with a mixture of 4 ml, 25 ml and 2 ml each of concentrated $HCLO_4$, HNO_3 and H_2SO_4 respectively, on a hot plate in a fume cupboard. On completion of digestion, it was cooled and 50 ml of de – ionized distilled water was added and then the samples filtered. The samples were made up to 100 ml with de-ionized distilled water and concentrations of the elements determined using atomic absorption spectrophotometer (AAS Model SP 9 Unicam 1984). This analysis was done at the National Research Institute for Chemical Technology (NARICT) Zaria for analysis of heavy metals in soils, vegetables and physiochemical characteristics of soil. Descriptive statistics such as mean was used and also inferential statistics such as Standard Deviation and Coefficient of Variation were used in this research. The relationship between heavy metal in soil and vegetable was evaluated using Correlation and Regression analysis at $p \leq 0.05$.

Vegetable samples

Samples of the leaves of vegetables (Cabbage and lettuce) were collected into labeled polythene bags and taken to the laboratory for analysis of heavy metals (Cu, Cr, Pb, Zn, Cd and Ni). One gram (1gm) each of milled/grounded homogenized samples was weighed with a digital weighing balance into a conical flask and digested in a mixture of 4ml, 25ml, 2ml and 1ml of concentrated $HCLO_4$ and 60% H_2O_2 respectively, at 100°C on a hot plate for two hours in a fume cupboard. The resulting solution was left over night and made up to 100ml with deionized distilled water and concentrations of the elements were determined. The guidelines for Maximum Limit (ML) of heavy metals in vegetables were adopted from World Health Organization (WHO) standard and FAO/WHO (2007). This analysis was done at the National Research Institute for Chemical Technology (NARICT) Zaria to determine the heavy metals (Cu, Cr, Pb, Zn, Cd and Ni) in soils and vegetables under study using the Atomic Absorption Spectrophotometer (AAS).

Results and Discussion

Table 1. Levels of concentration of Heavy metals in soils along Farin-Gada bridge (FGB)

Location	Pb(ppm)	Cd(ppm)	Zn(ppm)	Cu(ppm)	Cr(ppm)	Ni(ppm)
FGB1	0.0213	0.0142	0.0263	0.0061	0.0134	0.0073
FGB2	0.0021	0.0321	0.0251	0.0053	0.0722	0.0042
FGB3	0.0142	0.0227	0.0209	0.0096	0.0961	0.0116
FGB4	0.0212	0.0152	0.0237	0.0122	0.0611	0.0084
FGB5	0.0102	0.0232	0.0199	0.0116	0.0893	0.0163
FGB6	0.0267	0.1037	0.0285	0.0131	0.0193	0.0148
FGB7	0.0136	0.0117	0.0263	0.0084	0.0844	0.0182
FGB8	0.021	0.0121	0.0262	0.0113	0.0662	0.0093
FGB9	0.0312	0.0127	0.0219	0.0074	0.1173	0.0141
FGB10	0.021	0.0219	0.019	0.0083	0.1641	0.0122
FGB11	0.0421	0.1028	0.0261	0.0073	0.1152	0.0091
FGB12	0.0331	0.1126	0.0271	0.0063	0.1463	0.0009
mean	**0.0214**	**0.0404**	**0.0242**	**0.0089**	**0.0870**	**0.0105**
WHO Max level in soil	1.0	0.3	3.0	1.0	1.0	0.5

The table above shows that Chromium (Cr) has the highest mean occurrence of 0.0870ppm followed by Cadmium (Cd) with a mean concentration of 0.0404ppm, while Cupper (Cu) has the least mean occurrence of 0.0089ppm. Comparing these values with WHO/FAO Standards of 1.0ppm and 0.3ppm respectively, it shows that these metals are present in the soil but in negligible quantities.

Table 2. Levels and Concentration of heavy metals in vegetables at Farin-Gada bridge (FGB)

Location	Pb		Cd		Zn		Cu		Cr		Ni	
	Cb	Lt	Cb	Lt	Cb	Lt	Cb	Lt	Cb	Lt	Cb	Lt
FGB1	0.959	0.959	0.108	0.101	0.172	0.169	0.163	0.156	0.211	0.217	0.309	0.219
FGB2	1.031	0.992	0.121	0.116	0.078	0.062	0.319	0.193	0.286	0.282	0.319	0.231
FGB3	1.402	1.378	0.098	0.088	0.077	0.062	0.319	0.193	0.286	0.282	0.319	0.231
FGB4	0.955	0.932	0.112	0.097	0.201	0.196	0.271	0.203	0.210	0.190	0.748	0.643
FGB5	1.210	1.210	0.089	0.07	0.089	0.490	0.438	0.367	0.189	0.188	0.645	0.832
FGB6	1.082	0.988	0.215	0.197	0.490	0.322	0.722	0.699	0.199	0.180	0.153	0.178
Mean	**1.106**	**1.076**	**0.123**	**0.111**	**0.184**	**0.216**	**0.372**	**0.301**	**0.230**	**0.223**	**0.415**	**0.389**
WHO standard	**0.3**	**0.3**	**0.2**	**0.2**	**99.4**	**99.4**	**1.21**	**1.21**	**0.130**	**0.130**	**1.00**	**1.00**

Source: Researcher's Data (2019).

The table above shows that Lead (Pb) and Nickel (Ni) have the highest mean concentrations of heavy metals at 1.106ppm/ 1.076ppm and 0.123ppm/ 0.111ppm respectively for cabbage and lettuce while Cadmium (Cd) had the least mean concentration of 0.123ppm and 0.111ppm for cabbage and lettuce respectively. Comparing these concentrations with the WHO permissive level, it is evident that Lead (Pb) was found in vegetables far above the standard for human consumption. Though other metals were detected in the vegetables but were at a negligible quantity.

The presence of Lead (Pb) in high proportion in vegetables portent danger to consumers. Research in the past indicate that, consumption of vegetables with high quantity of Pb has a lot of health risks. Lead may accumulate in bone and lie dormant for years and then pose a threat later. Ingesting leafy vegetables grown in lead contaminated soil, storing acidic foods in improperly-glazed ceramics, battery manufacturing, demolition, painting and paint removal, smelting operations, and many more (Enenche and Sumaila, 2016).

Distribution of Heavy Metals in Soil

The mean values, standard deviation and CV of the selected heavy metals in all the selected areas were evaluated and presented in Table 1 and Fig 6 respectively.

Table 3: Mean Distribution of Heavy Metals and pH in Soil along Farin-Gada bridge

Statistics	Pb	Cd	Zn	Cu	Cr	Ni	pH ($CaCl_2$)
Mean	0.0214	0,04	0.02	0.089	0.087	0.0105	6.39
Std. Dev	0.01	0.04	0.00	0.00	0.05	0.01	
CV%	10.86	99.68	12.81	28.6	57.47	100.00	

Source: Researcher's Data 2019**.**

The result in table 3 reveals that Pb (0.092) and Cr (0.08) had the highest mean values at Farin-Gada bridge site as against Cu (0.021) and Zn (0.02) which had the lowest values. The reason for the high occurrence of Cu and Cr was due the fact that Farin-Gada bridge Fadama Site is located within the metropolitan area where a lot of human activities are carried out. Discharge from mechanic workshops and homes are likely sources of heavy metals within the study area.

The standard deviation was highest for Cr (0.05) and Cd (0.04) respectively. Furthermore, the results showed that Ni (100) and Cd (99.68) had the highest mean values of coefficient of variation. The least Cv occurred in Zn (12.81) and the mean soil pH at KB was 6.39.

Relationship between Heavy Metal in Soils and Vegetables

The relationship between heavy metals in soils and vegetables in the study sites were determined using Correlation and Regression analysis and presented in Tables 4 and 5 and the result reveals that relationships exist between soil and vegetables in the study area.

Correlation between metals in soil and vegetables

The relationship between heavy metals in soil and cabbage was determined using was evaluated using correlation statistics and presented in Table 4 which shows that there is a weak relationship existing between heavy metals in soil and cabbage in the study area.

Table 4: Correlation between metals in soil and vegetables

Heavy metals	Correlation coefficient (R^2)	p-values
Pb	0.16	1.86E-07
Cd	0.280	1.19E-13
Zn	0.2530	0.902461
Cu	0.0019	0.000896
Cr	0.0268	1.9613
Ni	0.1087	1.21007

Source: Researcher's Data (2019)

The results indicated that Cd (0.280) and Zn (0.253) had the highest relationship while Cu (0.0019) had the lowest relationship. This implies that increase in heavy metals in soil will not cause any corresponding increase in heavy metals in cabbage. The p-values were high in pb, cd, Cr, Ni and Zn but lowest in Cu.

Coefficient of Determination of Heavy Metals in soil and lettuce

The relationship of heavy metals in soil and cabbage was evaluated using coefficient of determination and presented in Table 5 where the results showed that relationships existed between heavy metals in soil and lettuce.

Table 5: Coefficient of Determination of Heavy Metals in soil and vegetables

Heavy metals	R^2	Adjusted R	Standard error of Estimate
Pb	0.030	0.001	0.4494
Cd	0.057	0.028	0.131
Zn	0.001	-0.028	0.246
Cu	0.007	-0.022	0.321
Cr	0.031	0.001	0.133
Ni	0.314	0.293	0.197

Source: Researcher's Data (2019)

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The findings indicated that Ni (0.34) had the highest R^2 value followed by Cd (0.057) signifying a strong relationship between heavy metals in soil and lettuce. Increase in Ni and cd in soil leads to a corresponding increase in lettuce. Heavy metals with weak relationship in the study area included pb (0.30), Zn (0.001), Cu (0.007) and Cr (0.031) which signifies that increasing these heavy metals in the soil does not lead to any increase in heavy metal content in lettuce.

At Farin Gada bridge, the summary of the result reveals that the mean concentration of metals in soil occurred most in pb (0.09) and Cr (0.08) while Zn (0.02) and Cu (0.01) had the least occurrence the metals occurred in the order pb (0.092)>Cr(0.8)>Cd(0.04)> Ni(0.03)>Zn(0.02)>Cu(0.01). The standard deviation was highest in pb (0.09) and cd (0.06) while Zn (0.010 and Cu (0.00) had the lowest values (Table 1). The coefficient of variation was highest in Cd (135.25) and Ni (106.61) with a mean pH value of 6.37.

Table 6 shows the comparison between heavy metals in the cabbage and lettuce with WHO standards, which revealed that pb (0.99 in cabbage and 1.05 in lettuce), Cr (0.20 in cabbage and 0.21 in lettuce) and Cd in lettuce exceeded the WHO standard.

Table 5: Comparison of HM in vegetables with WHO standard

	Heavy metals in Mg/kg					
Vegetables	Pb	Cd	Zn	Cu	Cr	Ni
Cabbage (cb)	0.99	0.14	0.20	0.26	0.20	0.43
Lettuce (lt)	1.05	0.44	0.22	0.32	0.21	0.30
WHO standard	**0.30**	**0.20**	**99.40**	**1.21**	**0.13**	**1.00**

Source: Researcher's Data (2018)/**WHO** International standards (2002)

Other metals such as Zn, Cu and Ni were far below the acceptable international standard. The metal with the least occurrence as compared with the international standard was Zn for cabbage and lettuce.

Conclusion

Based on the findings, it can be concluded that heavy metals were detected at all the study locations in soils and vegetables, though at different proportions, however, the concentrations were more in vegetables. Metals like Lead (Pb), Cadmium (Cd) and Chromium (Cr) were seen to have occurred above WHO standards, thereby constituting a serious health hazard to consumers. This was attributed to the fact that the use of farm inputs such as fertilizers, herbicides and fungicides increase the chances of adding heavy metals to the soil.

In order to create a sustainable agriculture, environmental balance and food security, the following recommendations were suggested:

i. Environmental Protection Agency which is saddled with the responsibility of sensitizing farmers and consumers on the harmful effect of consuming vegetables that contain heavy metals should step up their campaign to reduce the risk of contracting diseases.
ii. In order to maintain soil fertility, inorganic manure such as farm yard manure, compost and slash and burn ash should be used. The use of chemical fertilizers which contain heavy metals should be strictly based on professional advice.
iii. The cultivation of certain crops that are known not to accumulate heavy metals should be encouraged and their metabolic mechanisms studied.
iv. This research was based on two parameters i.e soil and vegetables. Further study could include water to actually ascertain its level of toxicity and consequent harmful effect on humans.

References

Adewumi, A. A., Edward, J. B., Idowu, E. O., Oso, J. O. Apalawo, A. O. (2017). Assessment of heavy metals in some fish species of Elemi River, Ado-Ekiti. *Agricultural Science Research Journal* Vol. 7(3): 103 – 110.

Alford, M. T., Hill, I. D., Rackham, L. J. and Tuley, P. (1979). *The Jos Plateau-A survey of environment and land use* (Morgan, W.T.W. ed.). Occasional Publications (New Series) No 14. Department of Geography, University of Durham, Durham, U.K.

Bartrem, C., Tirima, S., Worrell, M. C., Mohammad Anka, S., Moller, G. (2015). Unknown Risk: Co-exposure to lead and other heavy metals among children living in small-scale mining communities in Zamfara State, Nigeria. *International Journal of Environmental Health Research, 24*, 304–319.

Campbell, P. G. C. (2006). Cadmium-A priority pollutant, *Environmental Chemistry*, 3(6):387–388.

Chandran, S., Niranjana, V. and Benny, J. (2012). Accumulation of Heavy Metals in Wastewater Irrigated crops in Madurai, India. *Journal of Environmental Research and Development,* 6 (3), 432-438.

Edebi, N. V and Gideon, O.A (2017). Determination of Heavy Metals in medicinal plants from the Wild and cultivated Garden in Wilberforce Island, Niger Delta Nigeria. *Journal of pharmacy and pharmacognosy Research, 5 (2), 129-143*.

Enenche, D. E. and Sumaila, A. (2016). Appraisal of Heavy Metal in Soils using different digestion methods. *The pharmaceutical and Chemical journal* 3 (2) 201-206.

Even, F., and Ghaffari, S. (2011). Determination of Cadmium and Lead in Northern pike from the Missouri River. *American Journal of Undergraduate Res.* 10 (3): 15-20.

FAO/WHO (2007). Guidelines for the safe use of wastewater and food stuff. Waste-water use in Agriculture. Report by WHO, Geneva.

Henry, U.I., Egbere, O.J., Henry, M.U., Lawal, I.H., Ibrahim, I. (2016). Heavy metals content in fadama soils, root, leaf and seed of African locust bean tree (*Parkia biglobosa*) along the River Delimi in Jos North Local Government Area of Plateau state, Nigeria. *International Journal of Agronomy and Agricultural Research (IJAAR)*. 9(4): 36-43.

Hong, A. H., Law, P. L., Selaman, O. S (2014). Heavy Metal Concentration Levels in Soil at Lake Geriyo Irrigation Site, Yola, Adamawa State, Nigeria. *International Journal of Environmental Monitoring and Analysis*.2(2): 106-111.

Kawai, M. J. (2020). Concentration of Heavy metals in Soils and Vegetables in selected Fadama Farms in Jos Metropolis. An unpublished M.Sc. work, Bayero University, Kano.

Lenntech (2010). Heavy Metals.www.lenntech.com. Accessed on 2nd July, 2016. Pp.1-3.

Mahmoud, E., El-Kader, N. (2015). Heavy Metal Immobilization in contaminated soils using Phosphogypsum and rice straw compost. Land Degradation & Development, 26(8): 819-824.

Mustapha, H. I. and Omotaya, B. A (2014).Heavy metals accumulation in Edible part of Vegetables irrigated with untreated municipal wastewater in tropical savannah zone, Nigeria. *African journal of environmental science and technology*.8: 460-463.

Nasir, S. L., Owolona, A and Usman, A (2017). Health Risk Assessment of Heavy Metals in Soil, Irrigation water and Vegetables grown in Kubani River, Zaria. *Journal of physical science, Vol. 28 (1) 49-59*.

Ojo, A.A., (2014). Review on Heavy Metals Contamination in the Environment. *European Journal of Earth and Environment* Vol. 4 (1) pp 1-6.

Porter, G., Harris, F., Lyon, F., Dung, J. and Adepetu, A.A. (2002). *Markets, ethnicity and environment in a vulnerable landscape: the case of small-scale vegetable production on the Jos Plateau, Nigeria, 1991-2001*. Conference Paper of the RGS/IBG, Queens University, Belfast, 2-6 January 2002.

Rajagana Pathy V., Xavier F., Sreekumar D. and Mandal, P. K. (2011). Heavy Metal Contamination in Soil, Water, Fodder and their presence in Livestock Products: A Review. Journal of Environmental Science and Technology,4:234-249.